

CLEAR-AIR TURBULENCE AND METHODS OF DETECTION

First Semi-Annual Report under

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by

Electrical Engineering Research Laboratory

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RESEARCH OBJECTIVES

This is the first semi-annual report submitted in accordance with the requirements of NASA Grant NGR 44-012-048 which was effective April 1, 1966. This grant provides for a study of the characteristics of clear-air turbulence and methods for its detection.

The research during the period from April 1, 1966 through September 30, 1966 was directed toward the possibility of using radar techniques for the detection of CAT. The various phases of this research are as follows:

1. A review of available literature on the situations under which CAT occurs and the nature of the turbulence energy spectra observed or postulated.
2. An evaluation of the probable refractive index structure associated with CAT from the turbulence studies described in 1.
3. A theoretical study of backscattering cross section associated with the CAT refractive index structure discussed in 2 and with refractive index variations in general.
4. The measurement of refractive index differences at low levels and the comparison of these data with theoretical predictions. These variations are quite different from those at the elevations of occurrence of CAT. They are measurable, however, with a high degree of accuracy and these measurements and their comparison with theory should shed light on the potential radar return from CAT. In addition, they are of great value in a study of the meteorological processes in themselves and the effects that these processes have on radiowave propagation in general.
5. The measurement of radar return from inhomogeneities in the lower atmosphere. Radar operating at 3 cm and 10 cm have been used for measuring return from rain, clouds and "angels" by this laboratory. The radars are being improved in sensitivity for possible detection of scattered radio signals from atmospheric inhomogeneities.

RESEARCH STATUS

During the first six months of the grant period considerable progress has been made on the first four phases listed under "objectives." A technical report has been prepared for submission about October 15 covering the following topics:

- A. Locations and dimensions of CAT
- B. Mechanism, signature and structure of CAT
- C. Refractive index spectra associated with CAT
- D. A comprehensive list of references.

No attempt will be made here to go into detail on the material presented in the report since the topic headings are self-explanatory. It is felt, however, that the analysis and presentation in this report will provide an excellent starting point for further theoretical and experimental work on the characteristics and method of detection of CAT. With the submission of this report, items 1 and 2 under the objectives will be completed and the experimental and theoretical studies of the structure of the refraction in anomalies and their detection by radar will be emphasized.

Equipment has been assembled for the simultaneous measurement of refractive index differences. This has been done largely from components on hand. During July and August preliminary measurements with one and two differences in refractive index were made to develop the techniques for measurement and the method of analysis.

In September, four refractometers were put into operation on our 270 foot tower and measurements of a single refractive index sounding and the differences were made simultaneously. The refractometers were arranged in a three-dimensional array and in a linear array. Simultaneous measurements with a bivane anemometer provided the desired wind data.

Refractive index spectra and amplitude distributions are being run on the SDS930 computer in the Electrical Engineering Department. Although only a few of the possible aspects of the data have been examined, it is obvious that data have already been obtained from which many of the theories of atmospheric turbulence may be checked. These results will have an effect on the existing concepts of atmospheric anomalies.

A report is being prepared on the equipment used in these measurements. It will also present some of the data taken to date and the spectra determined from the data.

Another report is in preparation evaluating the theories of radar return from refractive index variations with emphasis on those found in CAT.

PERSONNEL

Dr. Archie W. Straiton, Professor of Electrical Engineering, has directed the research under the grant and devoted three fourths time to the project during the three summer months.

Dr. Alfred H. LaGrone, Professor of Electrical Engineering, Co-Principal Investigator, has served in a consulting capacity during the grant period without payment from the grant.

Mr. Andrew P. Deam, Special Research Associate, has been in charge of the experimental phases of the grant and has contributed to the theoretical analysis. Mr. Deam has devoted approximately 1/2 time to this project.

Dr. Jerry Stephens, Assistant Professor of Meteorology, was primarily responsible for the first technical report described earlier. He devoted full time to this work during the summer months. Dr. Elmar Reiter, Acting Head, Atmospheric Science Department, Colorado State University, served as a consultant for the project. He was in Austin for one week in June and one week in August and was very helpful in the analysis of the characteristics of CAT. He joined with Dr. Stephens the preparation of the first report.

Dr. Bob M. Fannin, Associate Professor of Electrical Engineering, has been concerned with the theoretical analysis of the radar scattering from disturbed refractive index regions and in interpretation of the refractive index difference measurements. He is preparing the second report covering the radar scattering.

Mr. Jimmy L. Dodd has been concerned with the measurement of refractive index differences and with the analysis of the data. He is a Ph. D. candidate and will use this study for his dissertation.

Mr. Allen Plunkett, another graduate student, is undertaking a study of the amount of scattering from a radar beam which would be seen at various angles. This will probably be his Master's thesis.

Visits

1. Dr. Archie W. Straiton has visited NASA Electronic Research Center on two occasions during the contract period. One of these was in the middle of April during the start of the research program and the other was on August 1, 1966. Conferences were held with Mr. Irving Etkind in April and with Dr. L. C. Van Atta, Mr. G. H. Trafford and Dr. Ralph Kotis on August 1st. Following these discussions, Dr. Straiton went to NASA offices in Washington for discussion with Mr. Wm. A. McGowan.

2. In the middle of July, Dr. Straiton and Mr. A. P. Deam visited Mr. Isadore Katz of the Applied Physics Laboratory of Johns Hopkins University for a detailed review of the observations made at Wallops Island with radars operating at three frequencies. Their observations on low level refractive index variation and the occasional observation of the tropopause are very significant and provide a key to the signal level which may be needed for CAT detection by radar. On the following day, Mr. Deam and Dr. Straiton went to Wallops Island for an inspection of the facilities.

3. As described in the proposal for the grant, Dr. Straiton was an official delegate to the XV General Assembly of the International Scientific Radio Union in Munich, Germany from September 3 to September 15. He attended this meeting as a part of this grant. The Commission 2 program was concerned with aspects of clear-air turbulence and refractive index differences. The status of the work of other investigators was presented at this meeting. It was obvious that this laboratory is headed in the right direction in our studies and that we are in the forefront of the atmospheric measurement work.

4. Professor P. M. Showers, Professor of Electrical Engineering at the University of Pennsylvania, visited this laboratory on July 29, 1966. Professor Showers discussed the research which they are doing on millimeter and sub-millimeter radio waves as they may be applicable to CAT detection. This work is being conducted for Electronics Research Center of NASA.

5. Trips to NASA Electronics Research Center on November 8, 1966 and to Boeing Aircraft Company in Seattle on December 6, 1966 are presently scheduled by Dr. Straiton. The trip to Seattle is to discuss the work which has been done on clear air detection.